Wastewater Treatment & Water Reuse

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Presentation Topics

- Water Regulations
- Definitions
- Wastewater Treatment
- Advanced Treatment
- Water Reuse & Comparison of Projects

Water Regulations

- Two overarching federal “acts” or regulations that are aimed at the cleanliness of water:
  - Safe Drinking Water Act (SDWA) – focused on standards for the human ingestion of water
    - Surface Water
    - Groundwater
    - Groundwater under the influence of surface water
  - Clean Water Act (CWA) – focused on standards for discharging a wastewater to a receiving water (stream, river, lake, etc.)
- No Federal standard for the production and distribution of reclaimed water
  - Each state has its own regulations (or not) for reclaimed water

The Water Cycle

Graphic credit:
www.healthywaterways.org

Definitions

- **Wastewater, sewage, black water** – water that has been used and now contains biological and chemical constituents in concentrations that pose a threat to environmental and human health.
- **Grey water, gray water** – water that has been used, but does not contain direct contributions of human waste (fecal matter and urine) or food waste. Contains low levels of biological and chemical components in concentrations that pose a low threat to environmental and human health.
- **Effluent** – water that has been cleaned up by a wastewater treatment plant and discharged to a stream, river, or lake.

Definitions (continued)

- **Reclaimed water, recycled water, repurified water** – water that has been cleaned up by a wastewater treatment plant or a water reclamation plant and purified to a level that is suitable for particular uses.

- **Water reuse, water recycling** – the practice of putting reclaimed water to a beneficial use, rather than discharging it to the environment according to CWA requirements.

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Flagstaff's Treatment Plants

Rio de Flag WRF

- Primary sedimentation
- Activated sludge
- Secondary sedimentation
- Dual media gravity filtration or disc filters
- UV disinfection

- Turf irrigation
- Landscape irrigation
- Golf course
- Construction water
- Paper manufacturing
- Toilet flushing
- Discharge

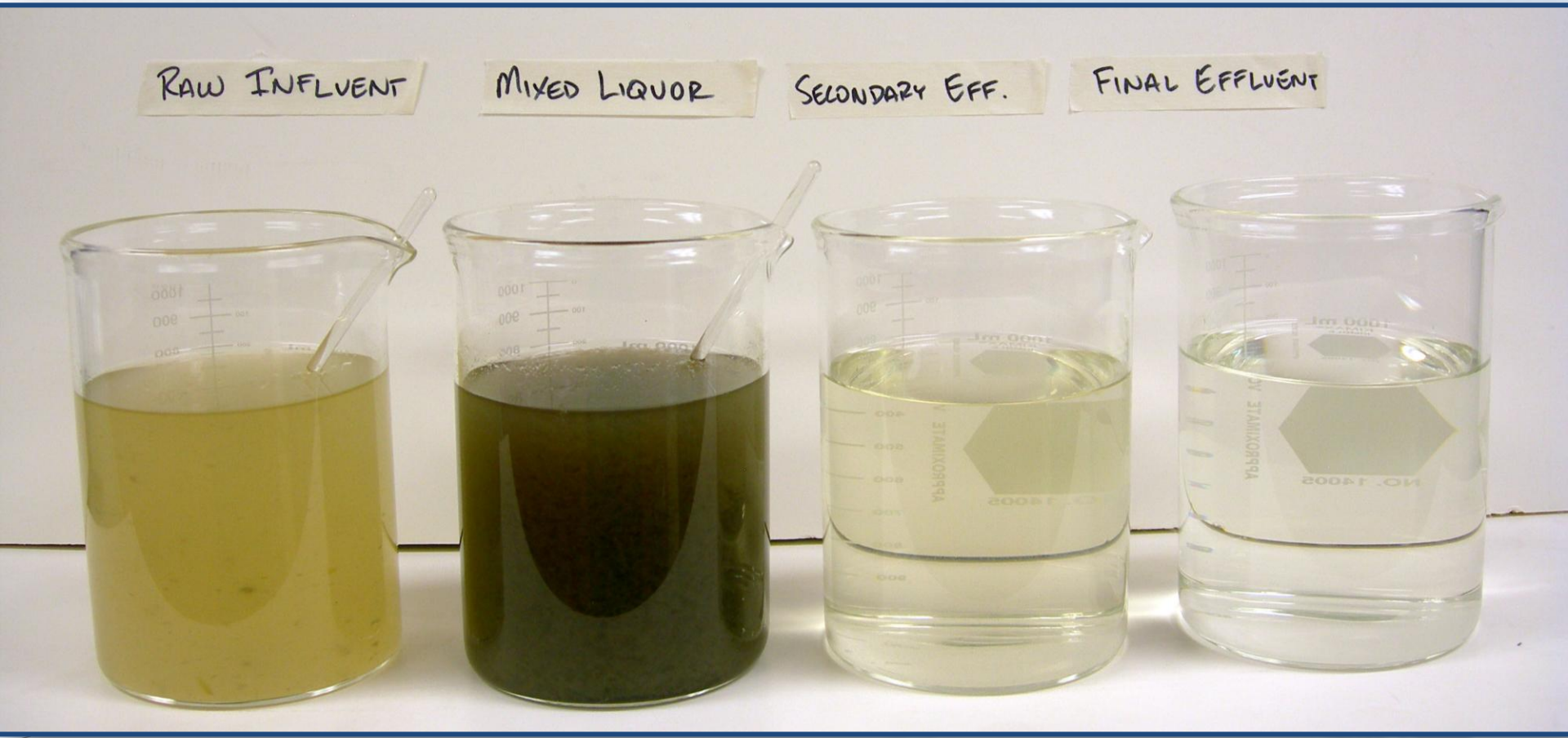
Wildcat Hill WRF

- Primary sedimentation
- Activated sludge
- Secondary sedimentation
- Dual media gravity filtration or disc filters
- Chlorine gas for disinfection
- SO_2 gas for dechlorination

- 2 golf courses
- Discharge

Both Plants Produce Class A+ Reclaimed Water

Wastewater to Reclaimed Water



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Conventional Wastewater Treatment Does a Great Job of Treating Sewage

- But Can Only Go So Far in Removing Trace Organic Chemicals
  - Optimizing conventional treatment can reduce the levels of some organic chemicals.
  - Other chemicals, (i.e., pharmaceuticals) are resistant to biological processes.
  - Different treatment technologies may be needed to reduce or remove certain chemicals.

Trace Organic Compounds Come From Many Sources

Antibacterial hand soap
triclosan

Birth control pill
ethinyl estradiol

Coffee
caffeine

Polycarbonate plastic
bisphenol-a

Fire extinguisher
TDCPP, TCEP, TCPP

Insect repellent
DEET

Compounds shown represent only a small portion of all compounds to be analyzed

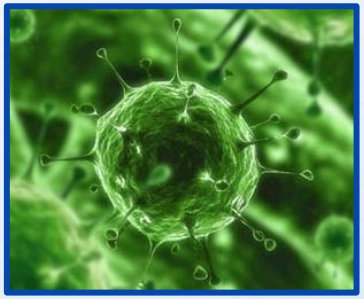
Approaches

- Optimize the secondary process (activated sludge)
  - Find optimal retention times (size of tank and the microorganism population – bigger tanks, more recirculation)
  - Handle return flows differently (some of the return flows have high concentrations of EDCs; can treat these separately) – includes centrate from solids handling
- Optimize particle removal through filtration
- Add Advanced Oxidation to end of existing plant
- Add Microfiltration, Reverse Osmosis + Advanced Oxidation Process to end of existing plant

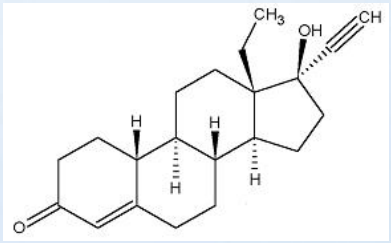
Membranes Can Effectively Remove Most Trace Organics

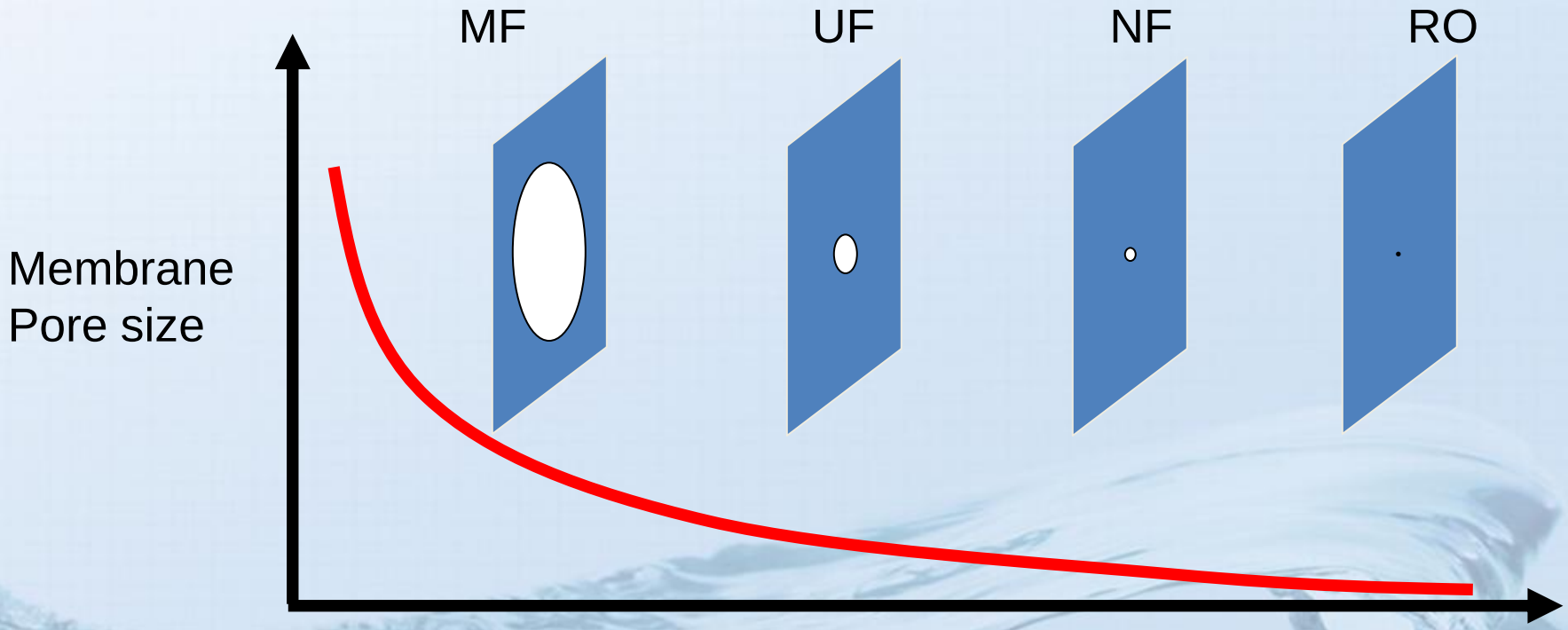
Bacteria

Viruses

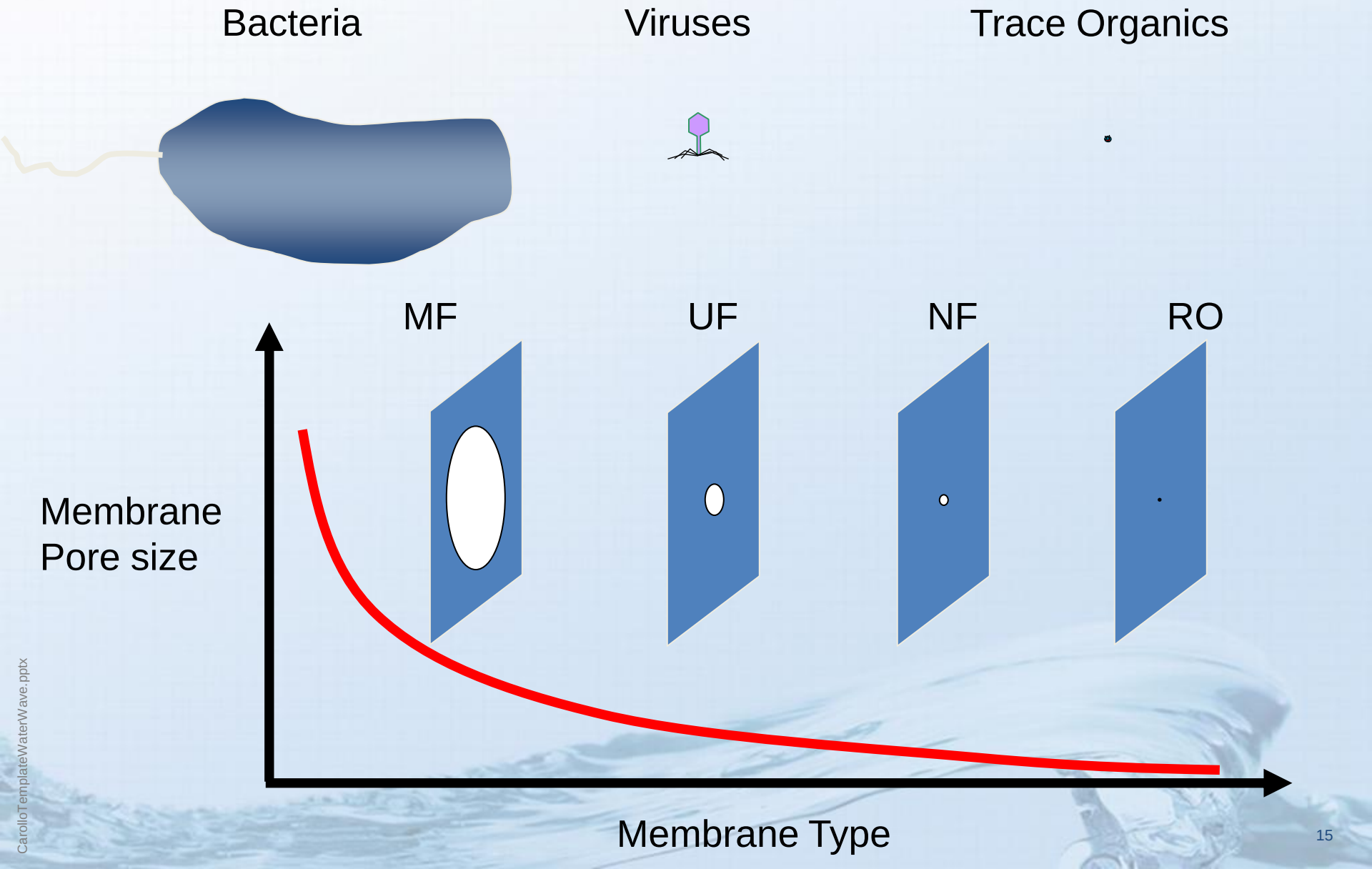


Trace Organics





Membranes Can Effectively Remove Most Trace Organics



The most common approach to removing trace organic chemicals is MF/RO + AOP

- Microfiltration (MF) followed by reverse osmosis (RO) removes most trace organic compounds.
- More persistent compounds can be destroyed to a large degree by advanced oxidation processes (AOP):
  - Ozone
  - Ultraviolet radiation (UV)
  - Hydrogen Peroxide
  - Peracetic acid
- “Oxidation” means we are removing electrons from the compound, which forces it to break apart.

However, Microfiltration plus Reverse Osmosis Followed by Advanced Oxidation is “Overkill” for Traditional Water Reuse

- It takes a lot of energy to push (pump) water through membranes
- Recent research shows that advanced oxidation following regular filtration can accomplish similar results

Cost Implications of Deciding to Reduce Trace Organic Compound Concentrations for a 10 MGD Treatment Plant (add to end of existing process)

Treatment Technology	Capital Cost	Annual O&M	EEq Destruction
NaOCl (free chlorine residual)	$7,532,000	$219,000	~75%
Medium Pressure UV + Hydrogen Peroxide	$8,923,000	$509,000	>90%
Medium Pressure UV + Peracetic Acid	$9,563,000	$1,645,000	60%
Ozone	$8,828,000	$217,000	>90%
Titanium Dioxide with UV	$15,941,000	$311,000	>90%
MF/RO + UV & H_2O_2	$45,601,000	$2,470,000	>95%

EEq is Estradiol Equivalent; a measure of hormonal activity

If your goal is to remove almost all pharmaceuticals below detectable levels…

- Each person in Flagstaff can spend
  - approximately $700 for MF/RO + AOP (one time cost)
    - + $38/person/year to operate
    - >95% removal of most of the trace organic compounds

    OR
  - approximately $140 for Ozone (one time cost)
    - + $3.30/person/year to operate
    - >90% removal of most of the trace organic compounds

Based upon population of 65,870

"removal" means destruction to below detection limit

If your goal is to remove most pharmaceuticals below detectable levels…

- Each person in Flagstaff can spend
  - approximately $76 for modifying existing plant and installing side-stream treatment
    - +$1.14/person/year to operate
    - >75% removal of most trace organic compounds

    OR
  - approximately $23 for optimizing the existing plant without making any structural changes
    - + $0.76/person/year to operate
    - >50% removal of most trace organic compounds

Based upon population of 65,870

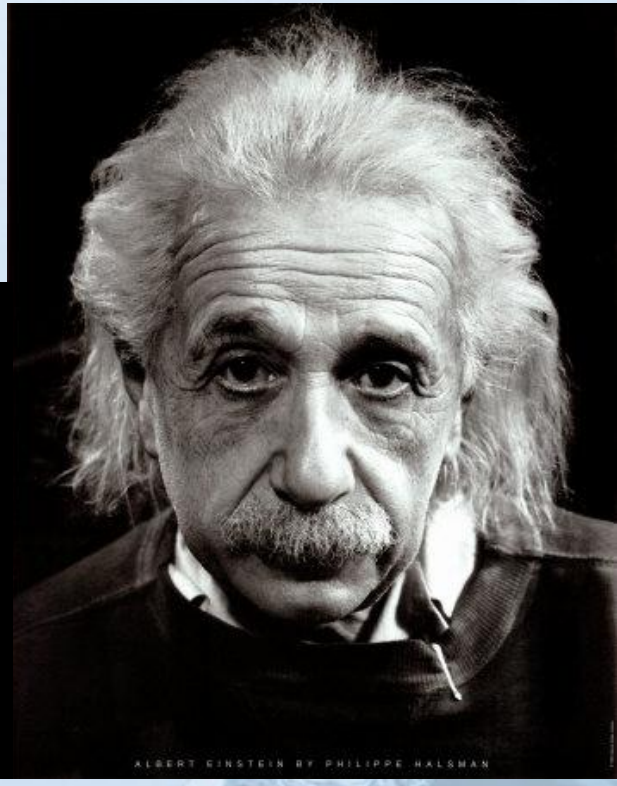
"removal" means destruction to below detection limit

Or, you can wait to see if regulations will be developed based upon science and defer your decision until later

- Risk assessments associated with trace organic chemicals may drive changes to how water gets treated and reused
  - What we know right now tells us there are little to no human health impacts of Class A+ Reclaimed Water

"Not everything that counts can be counted, and not everything that can be counted, counts."

Albert Einstein

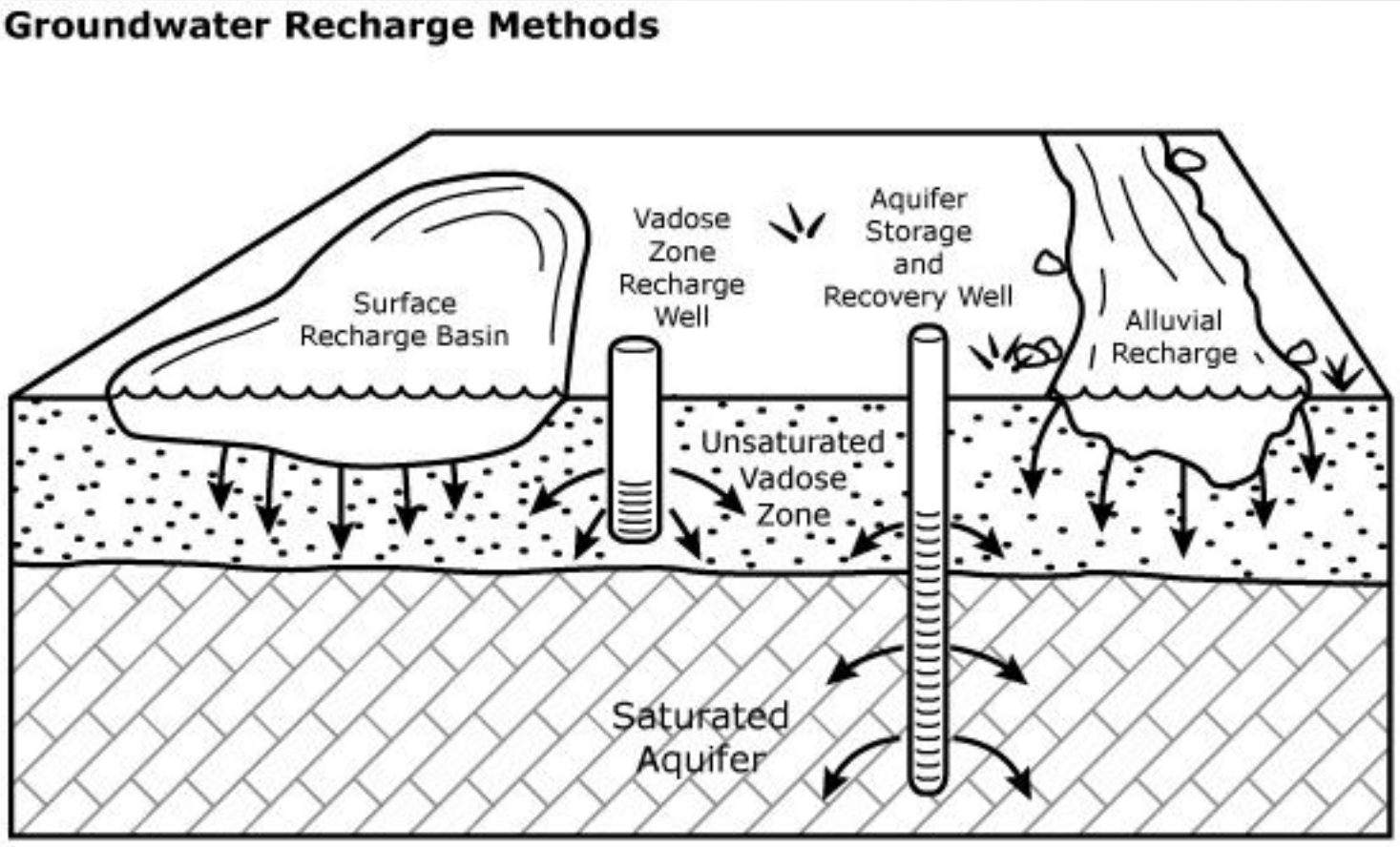


THE PRACTICE OF WATER REUSE

Typical Applications

- Landscape irrigation
- Agricultural irrigation (edible & non-edible crops)
- Power production (steam & cooling)
- Industrial and commercial
- Environmental uses
- Non-potable urban uses (urinal flushing in high rise buildings)
- Groundwater recharge
- Potable water supply augmentation

Augmentation



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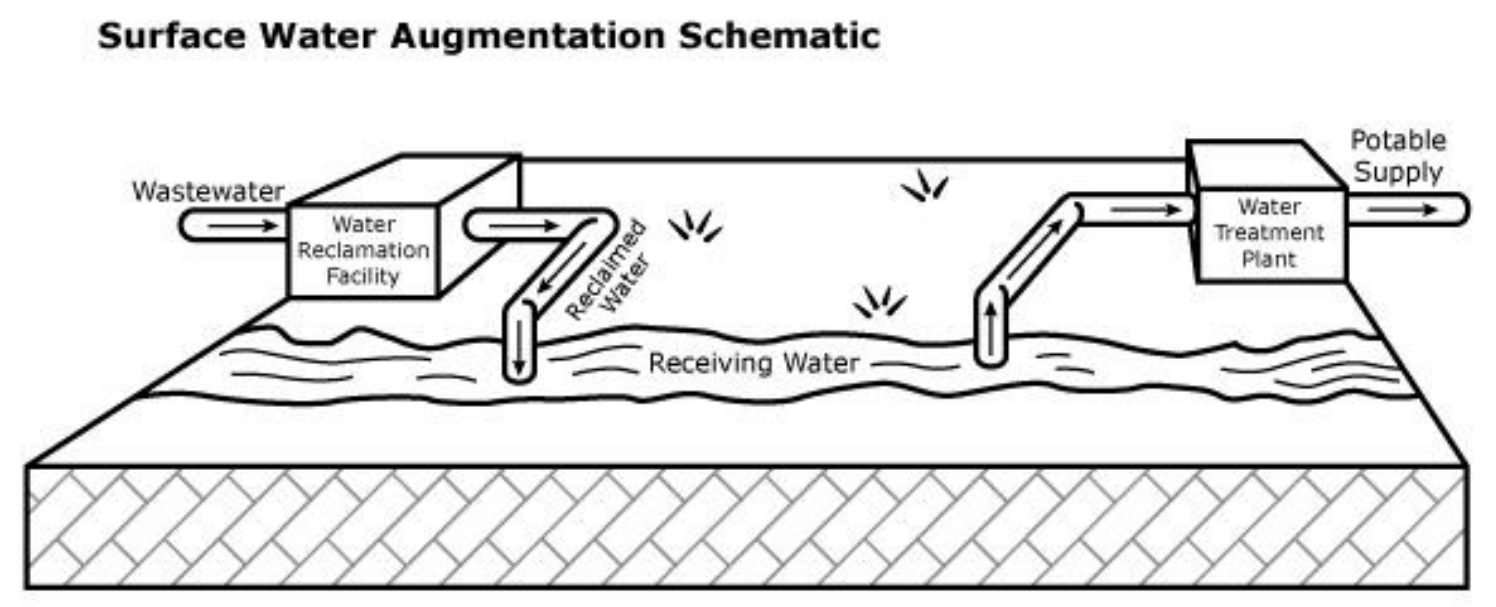
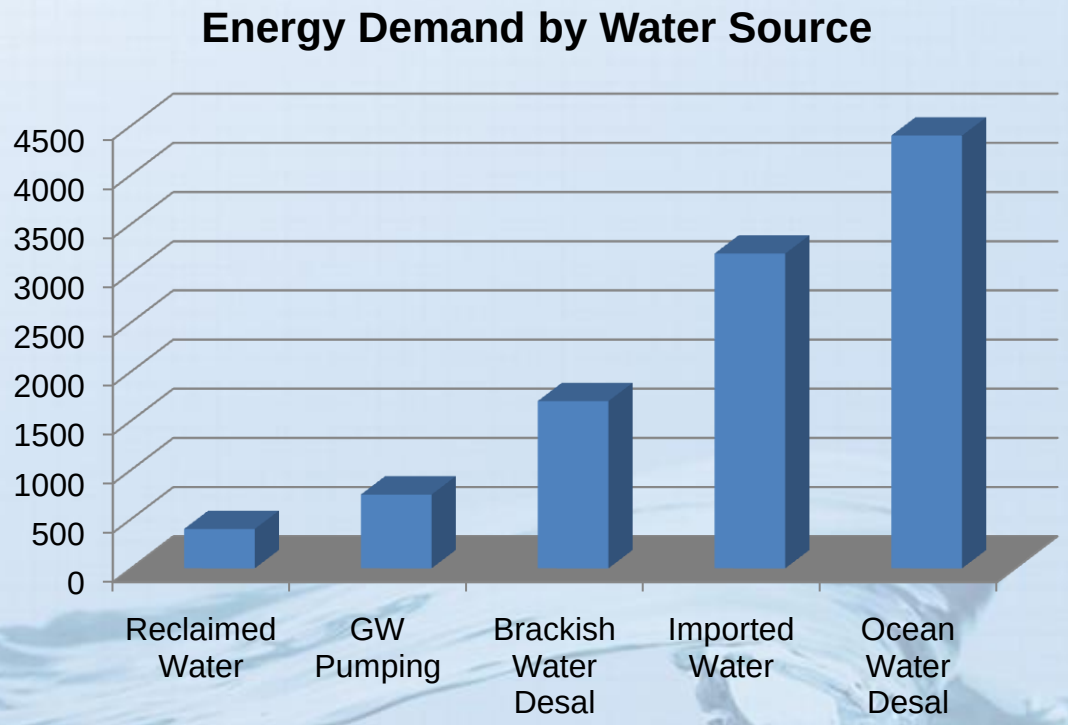


Benefits

- Dependable source of supply
- Reliable, consistent quality
- Locally controlled; right to use
- Lower carbon footprint
- Low capital costs
  (relative to other sources of supply)
- Augments existing supplies



A Comparison of Projects

Project	Approach	Intentional Reduction of Trace Organic Chemicals?	Cost / MGD of Treatment Capacity
Hypothetical: Flagstaff to Optimize Existing Facilities	Optimize tank sizes, enhance recirculation , treat recirc. water, enhance filtration	Yes	< ~$0.5M
Hypothetical: Flagstaff to add Ozone to both Facilities		Yes	~$1.0M
Tucson Water (AZ) Reuse & Sweetwater Wetlands	Reclaimed water for irrigation; Treatment wetlands & groundwater recharge	No	<$1M Recharge Basins
Town of Gilbert (AZ) Reuse & Groundwater Recharge	Reclaimed water for irrigation; groundwater recharge	No	$1.3M Recharge Basins
City of Scottsdale (AZ) Water Reuse and Advanced Water Treatment	Reclaimed water for irrigation; higher quality water for groundwater recharge	Yes	$5.0M Advanced Treatment & Recharge Wells
Orange County Water District (CA) Groundwater Replenishment System	MF/RO + UV & hydrogen peroxide for groundwater recharge	Yes	$6.9M Advanced Treatment & Recharge Wells
Hypothetical: Flagstaff to add MF/RO + UV & H_2O_2	Advanced filtration and advanced oxidation process	Yes	~$4.5M to 7.0M Advanced Treatment
Cloudcroft (NM) PUReWater Project	RO + UV & hydrogen peroxide, blend with other water, UF, UV, activated carbon, then disinfection for drinking	Yes	$19.4M Advanced Treatment & Subsequent Drinking Water Treatment

Closing Thoughts

- The idea of “pristine water” is utopian.
- However, the water industry is taking the presence of trace organic chemicals seriously.
- Technology and controls, including natural systems, can be used to treat water for identified needs.
- You are the rate payers; you own the system; it is your decision and your money that pays for water quality and reliability.